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Toebes et al.

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(54) **METHOD AND SYSTEM FOR CONTROLLING TRANSMISSION OF USB MESSAGES OVER A DATA NETWORK BETWEEN A USB DEVICE AND A PLURALITY OF HOST COMPUTERS**

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(58) **Field of Classification Search** 710/200, 710/315, 37, 305, 241, 106–108, 316; 370/254, 370/402, 466, 474
See application file for complete search history.

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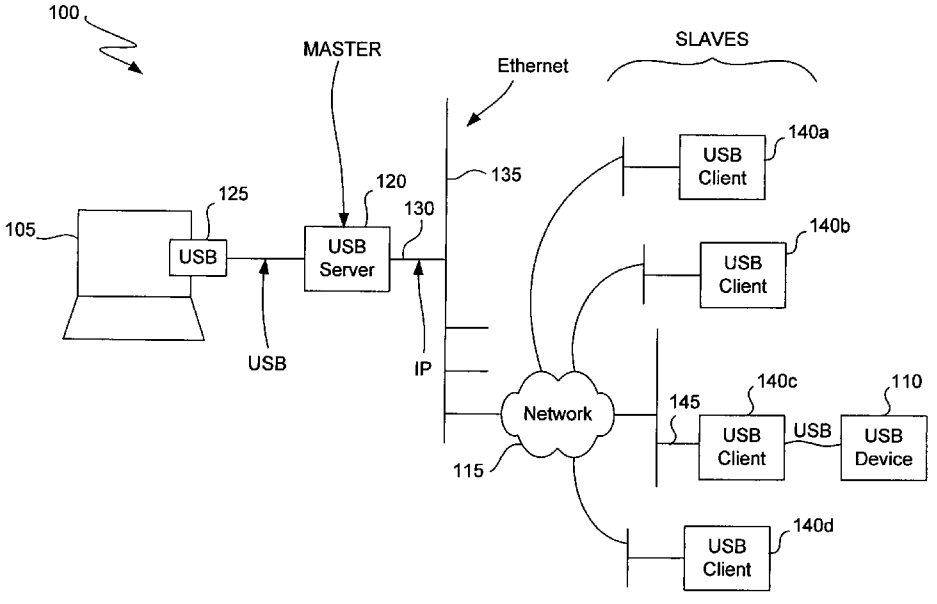
(57) **ABSTRACT**

A solution is provided for controlling universal serial bus (USB) messages between a plurality of host computers and a USB device. First and second USB servers may communicate with first and second host computers, respectively. A USB client may then communicate with the USB device. A first control path between the USB client and the first USB server and a second control path between the USB client and the second USB server may be established. Then a first data transfer path may be established between the USB client and the first USB server, the first data transfer path enabling the sending of data between the USB client and the first USB server over a data network. Then a busy message may be sent from the USB client to the second USB server over the second control path when the first data transfer path is established with the first USB server.

35 Claims, 12 Drawing Sheets



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USPTO Office Action issued in related U.S. Appl. No. 11/006,988 dated Jun. 12, 2008 (22 pages).

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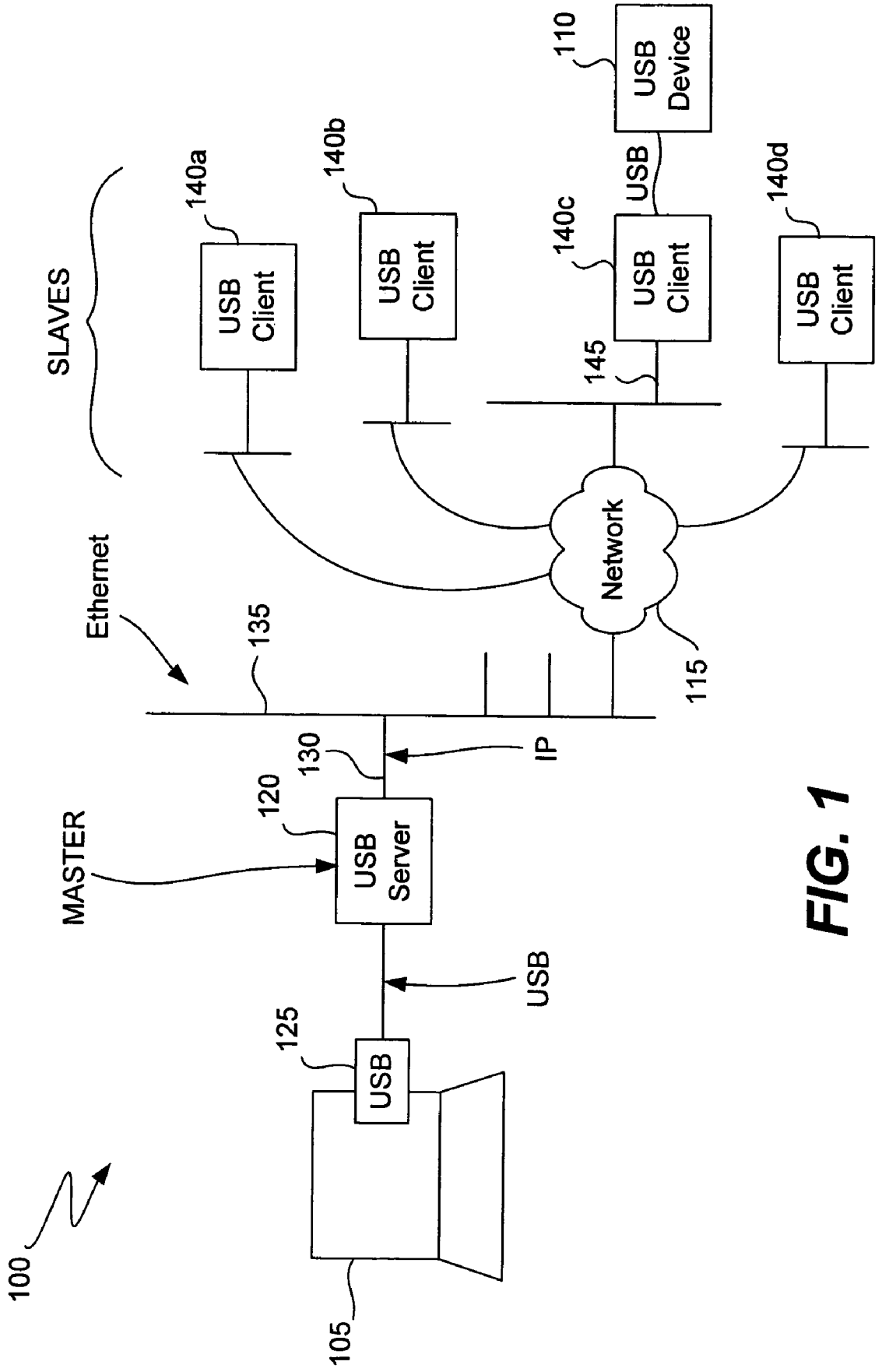
100
105
125
USB
USB Server
120
MASTER
130
IP
135
Ethernet
SLAVES
140a
USB Client
140b
USB Client
140c
USB Client
140d
USB Client
145
USB
110
USB Device
Network
115

FIG. 1

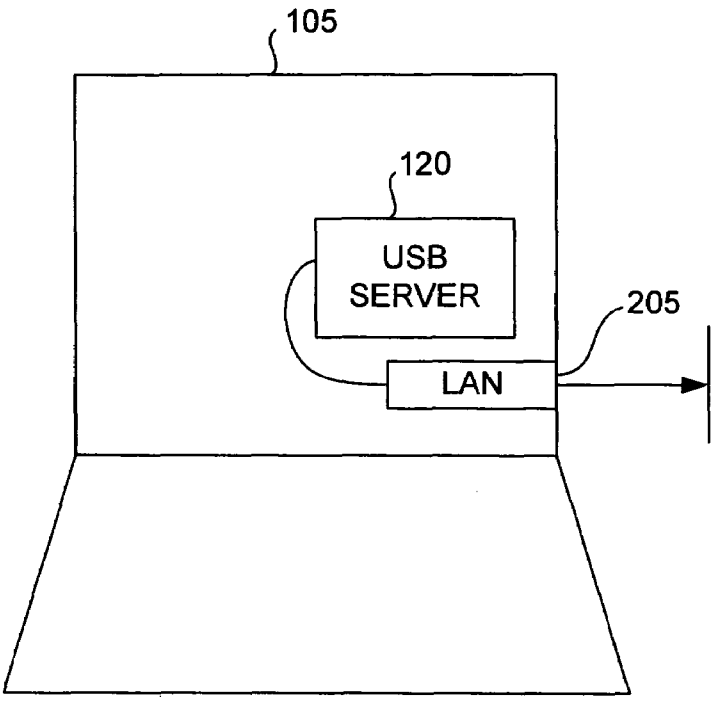
105
120
USB
SERVER
205
LAN

FIG. 2

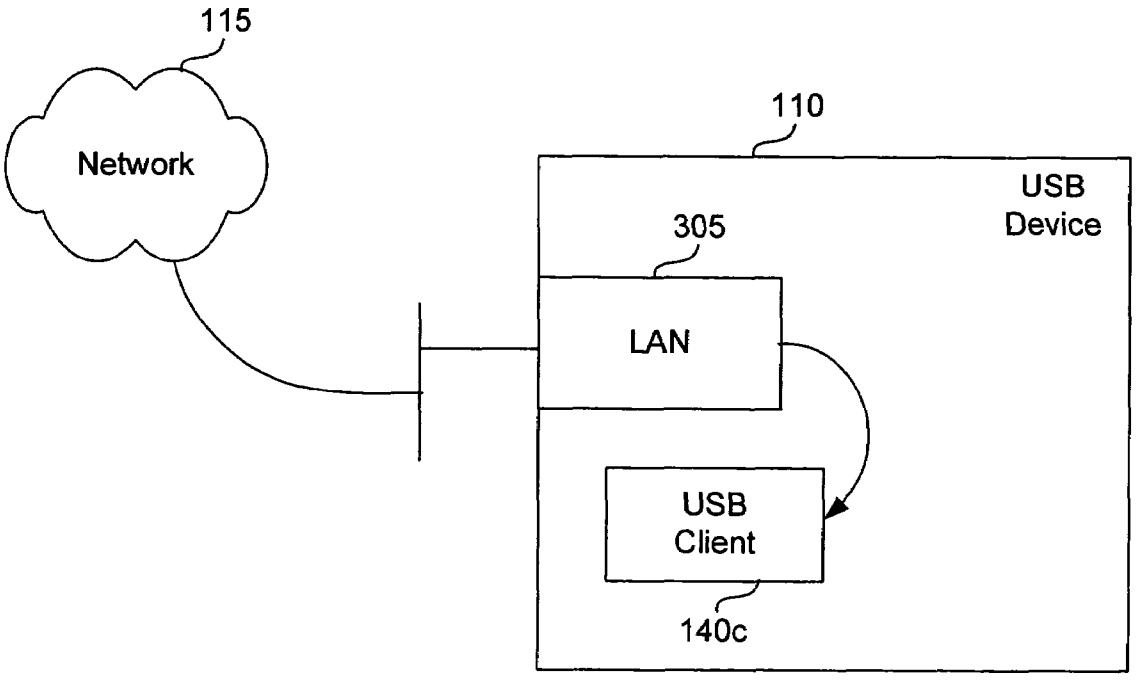
115
Network
110
USB
Device
305
LAN
USB
Client
140c

FIG. 3

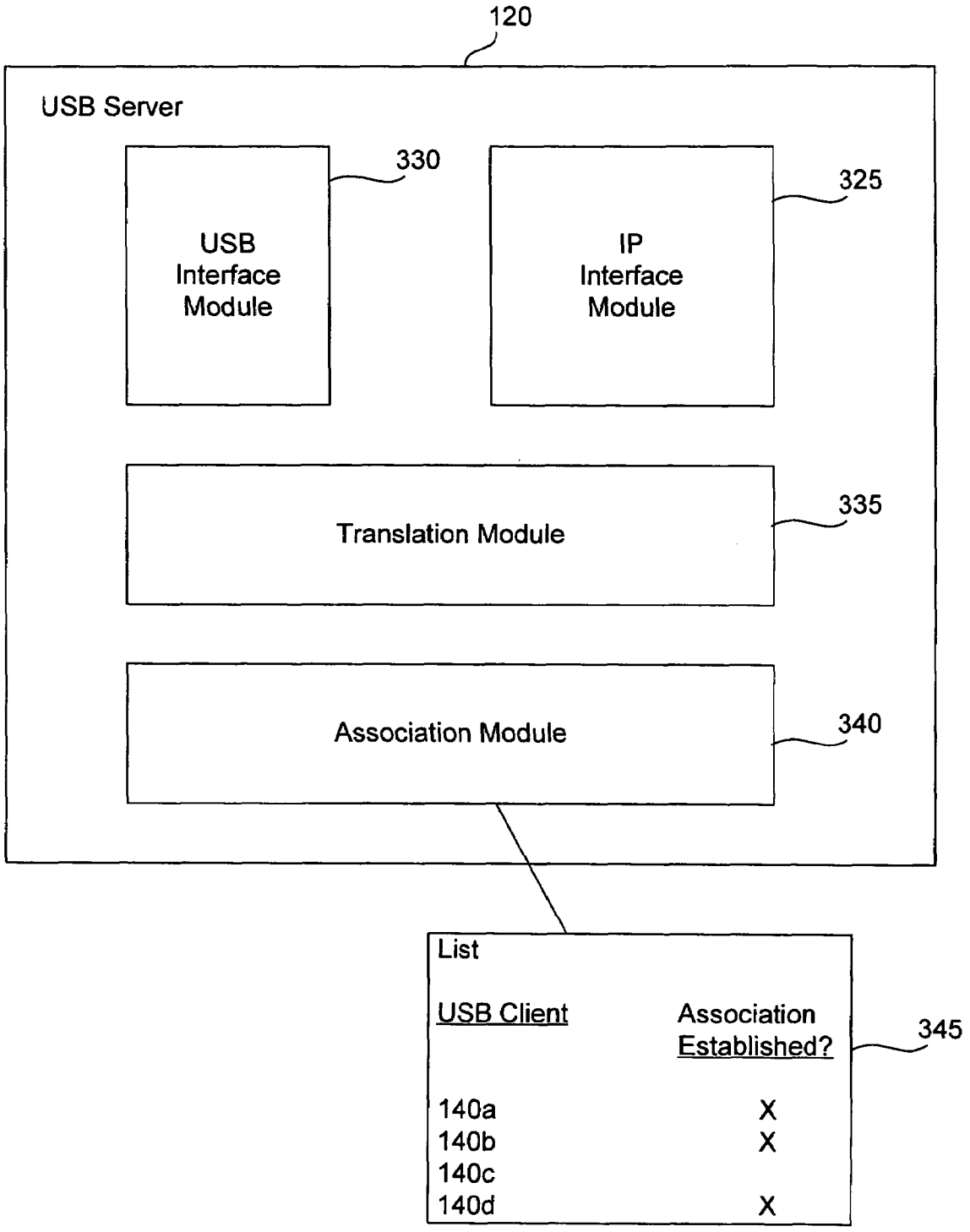
120
USB Server
330
USB Interface Module
325
IP Interface Module
335
Translation Module
340
Association Module
List
USB Client
Association Established?
345
140a X
140b X
140c
140d X

FIG. 4A

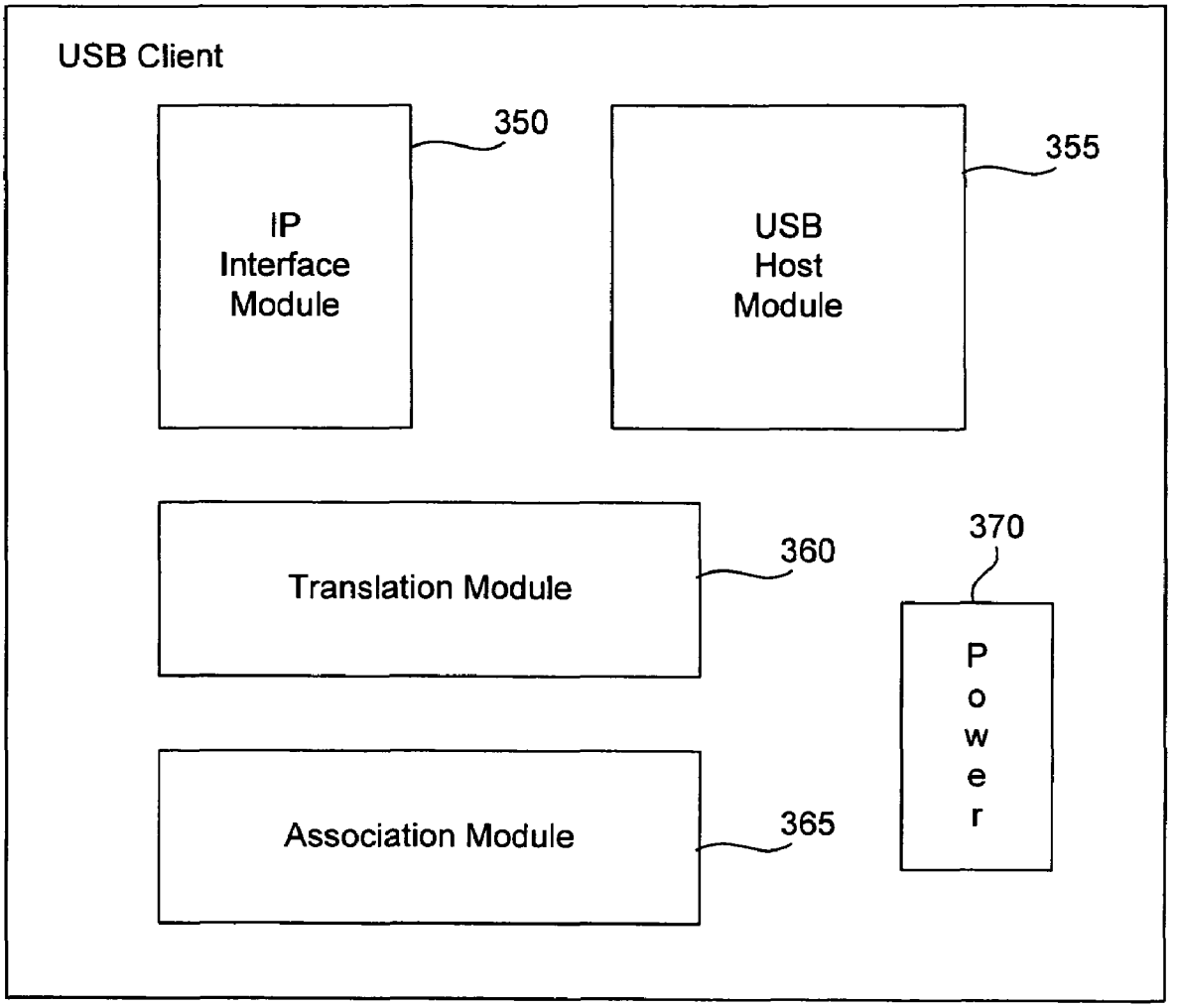
USB Client
IP Interface Module
350
USB Host Module
355
Translation Module
360
370
Power
Association Module
365

FIG. 4B

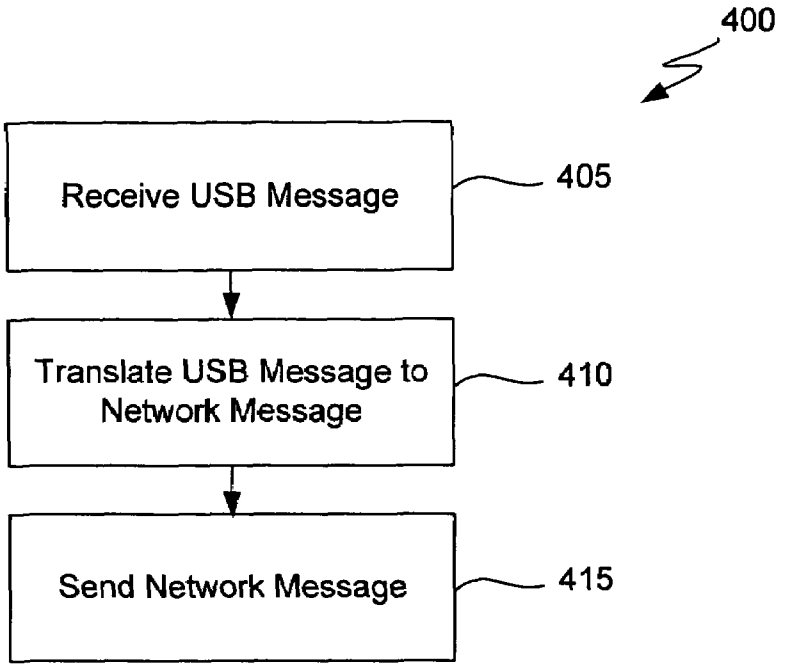
400
Receive USB Message
405
Translate USB Message to Network Message
410
Send Network Message
415

FIG. 5A

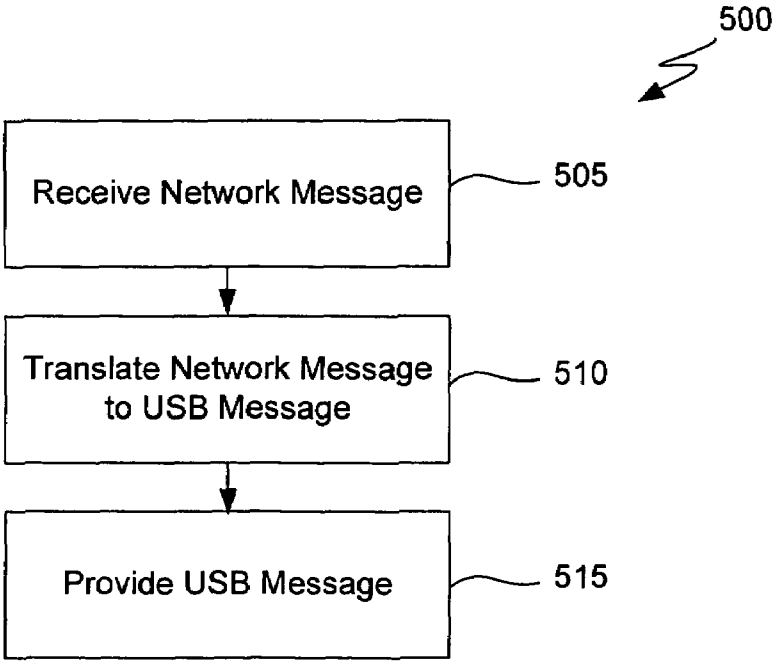
500
Receive Network Message
505
Translate Network Message to USB Message
510
Provide USB Message
515

FIG. 5B

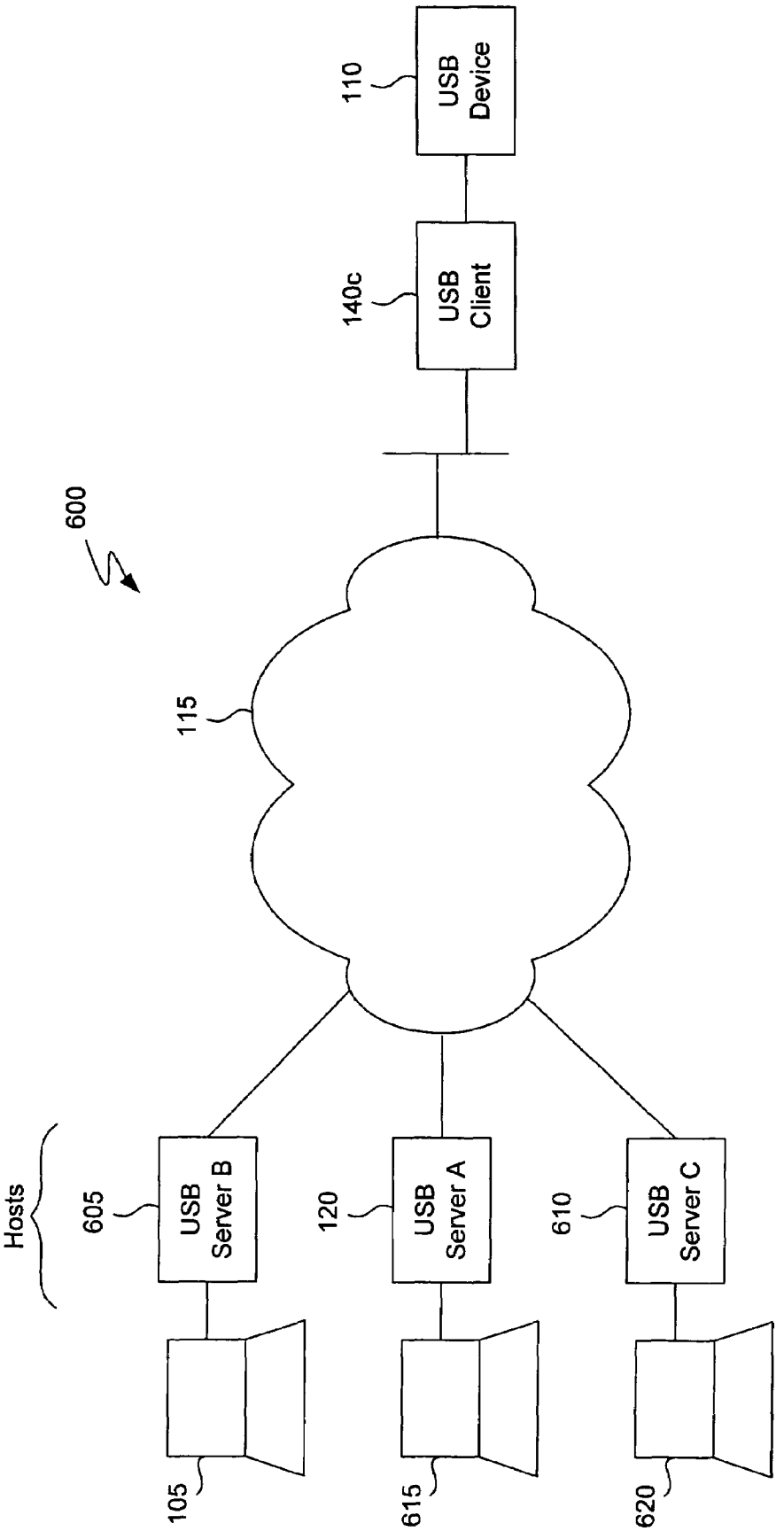
600
110
USB Device
140c
USB Client
115
Hosts
605
USB Server B
120
USB Server A
610
USB Server C
105
615
620

FIG. 6

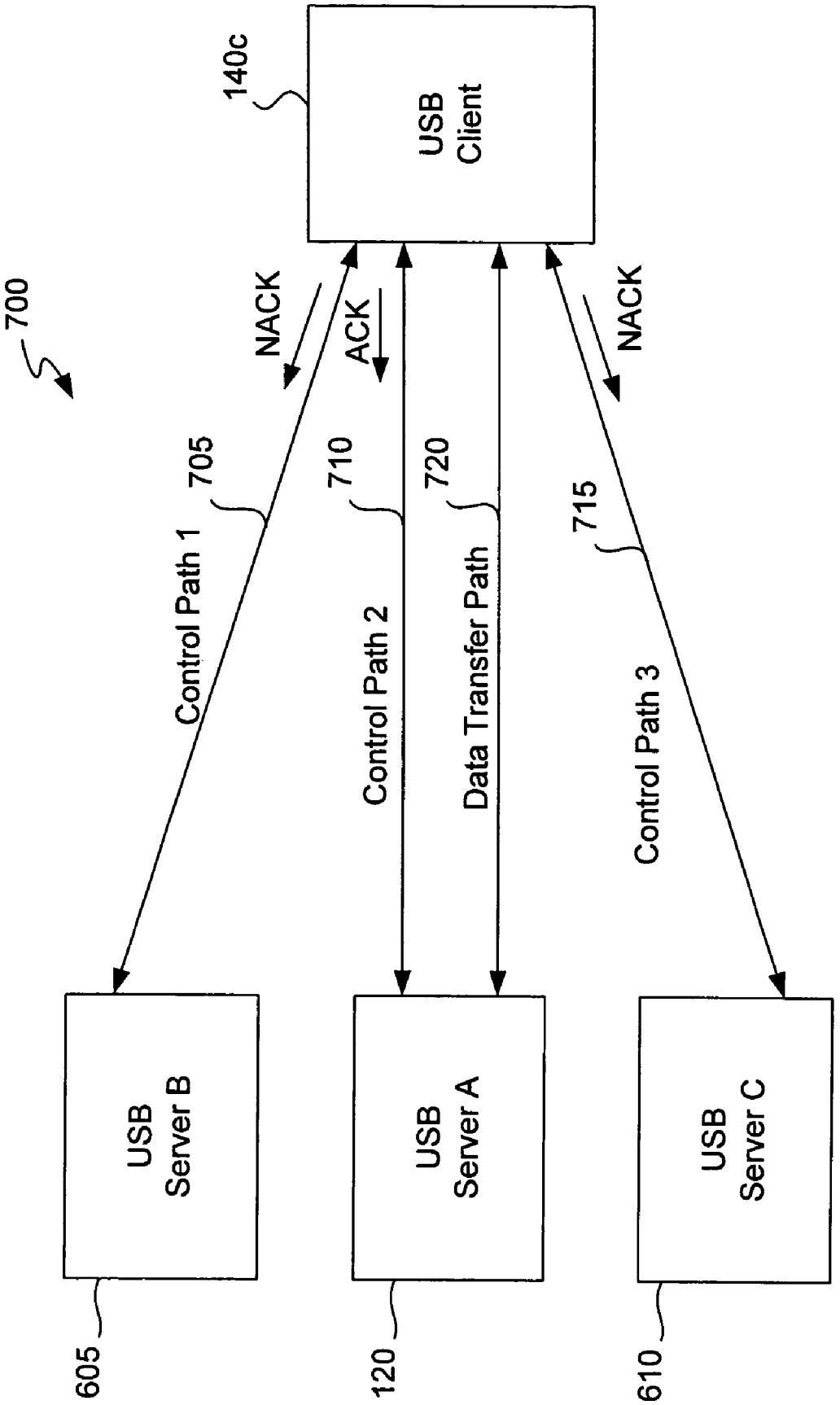
700
140c
USB Client
NACK
ACK
NACK
705
710
720
715
Control Path 1
Control Path 2
Data Transfer Path
Control Path 3
USB Server B
USB Server A
USB Server C
605
120
610

FIG. 7

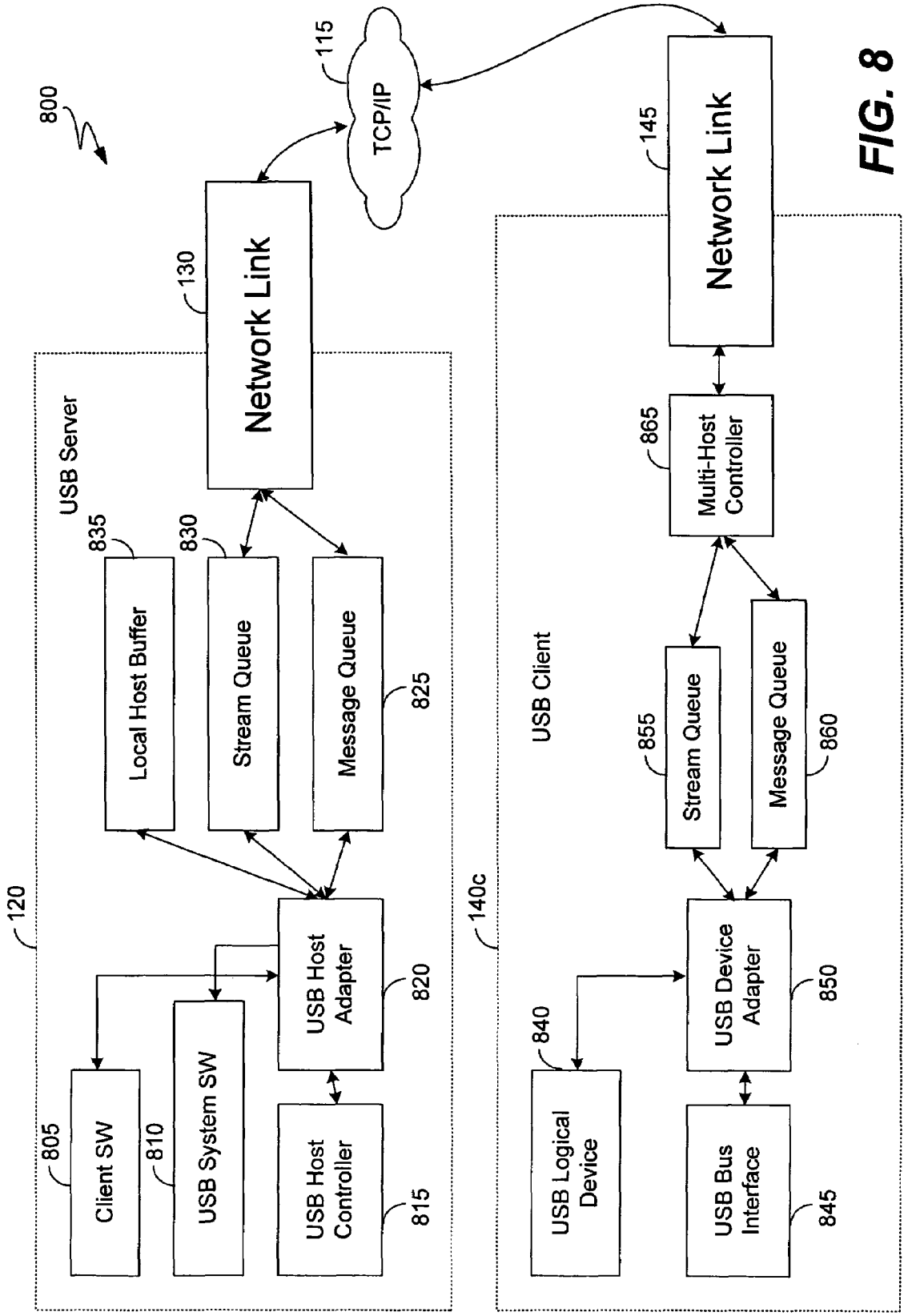
800
115
TCP/IP
130
Network Link
145
Network Link
USB Server
835
830
Local Host Buffer
Stream Queue
Message Queue
825
865
Multi-Host Controller
120
USB Client
855
Stream Queue
Message Queue
860
140c
USB Host Adapter
820
USB Device Adapter
850
805
Client SW
810
USB System SW
840
USB Logical Device
USB Host Controller
815
USB Bus Interface
845

FIG. 8

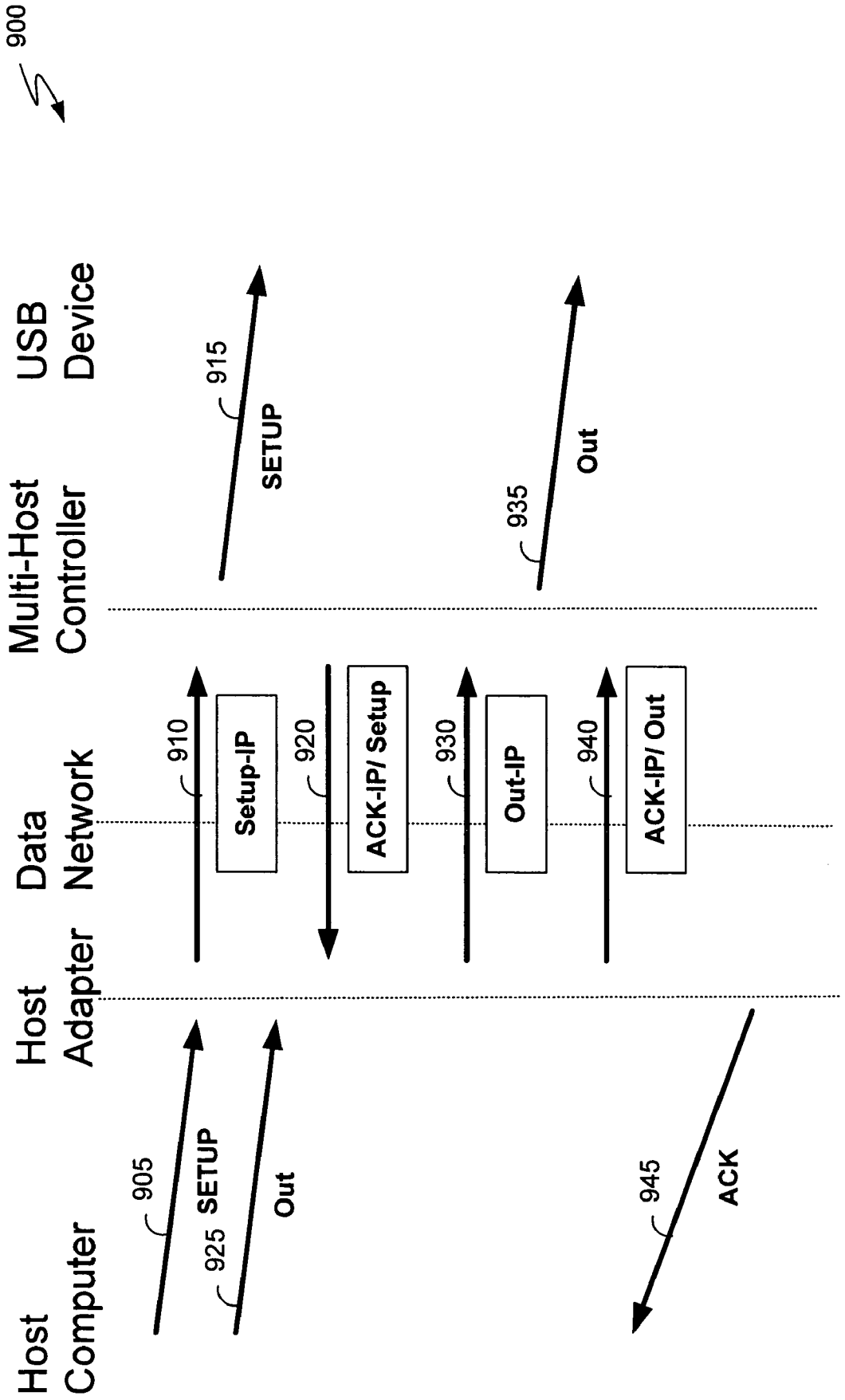
900
Host Computer
Host Adapter
Data Network
Multi-Host Controller
USB Device
905
SETUP
925
Out
910
Setup-IP
920
ACK-IP/ Setup
930
Out-IP
940
ACK-IP/ Out
915
SETUP
935
Out
945
ACK

FIG. 9

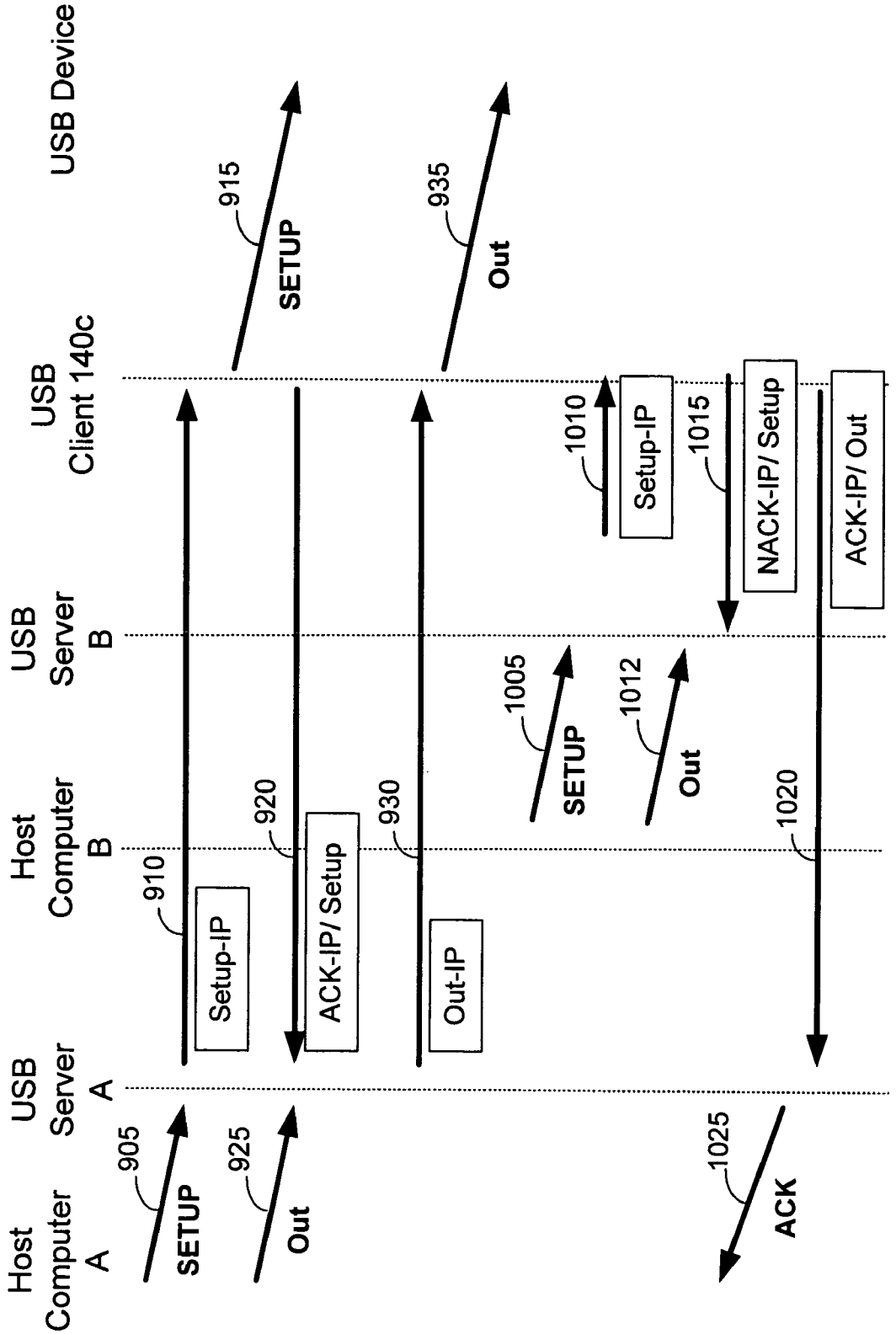
Host Computer A
USB Server A
Host Computer B
USB Server B
USB Client 140c
USB Device
905
SETUP
910
Setup-IP
915
SETUP
920
ACK-IP/ Setup
925
Out
930
Out-IP
935
Out
1005
SETUP
1010
Setup-IP
1012
Out
1015
NACK-IP/ Setup
1020
ACK-IP/ Out
1025
ACK

FIG. 10A

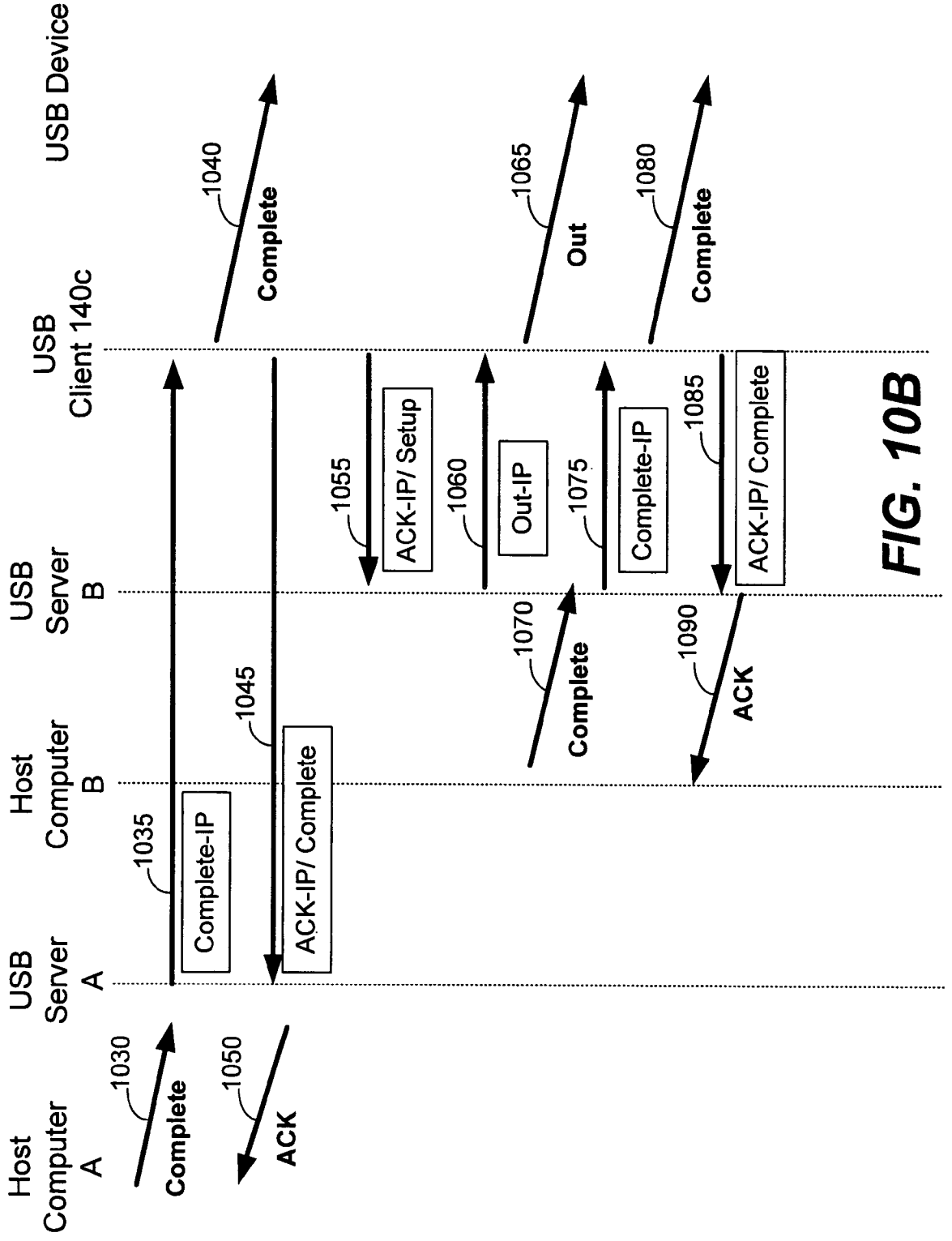
Host Computer A
USB Server A
Host Computer B
USB Server B
USB Client 140c
USB Device
1030
Complete
1035
Complete-IP
1040
Complete
1045
ACK-IP/ Complete
1050
ACK
1055
ACK-IP/ Setup
1060
Out-IP
1065
Out
1070
Complete
1075
Complete-IP
1080
Complete
1085
ACK-IP/ Complete
1090
ACK

FIG. 10B

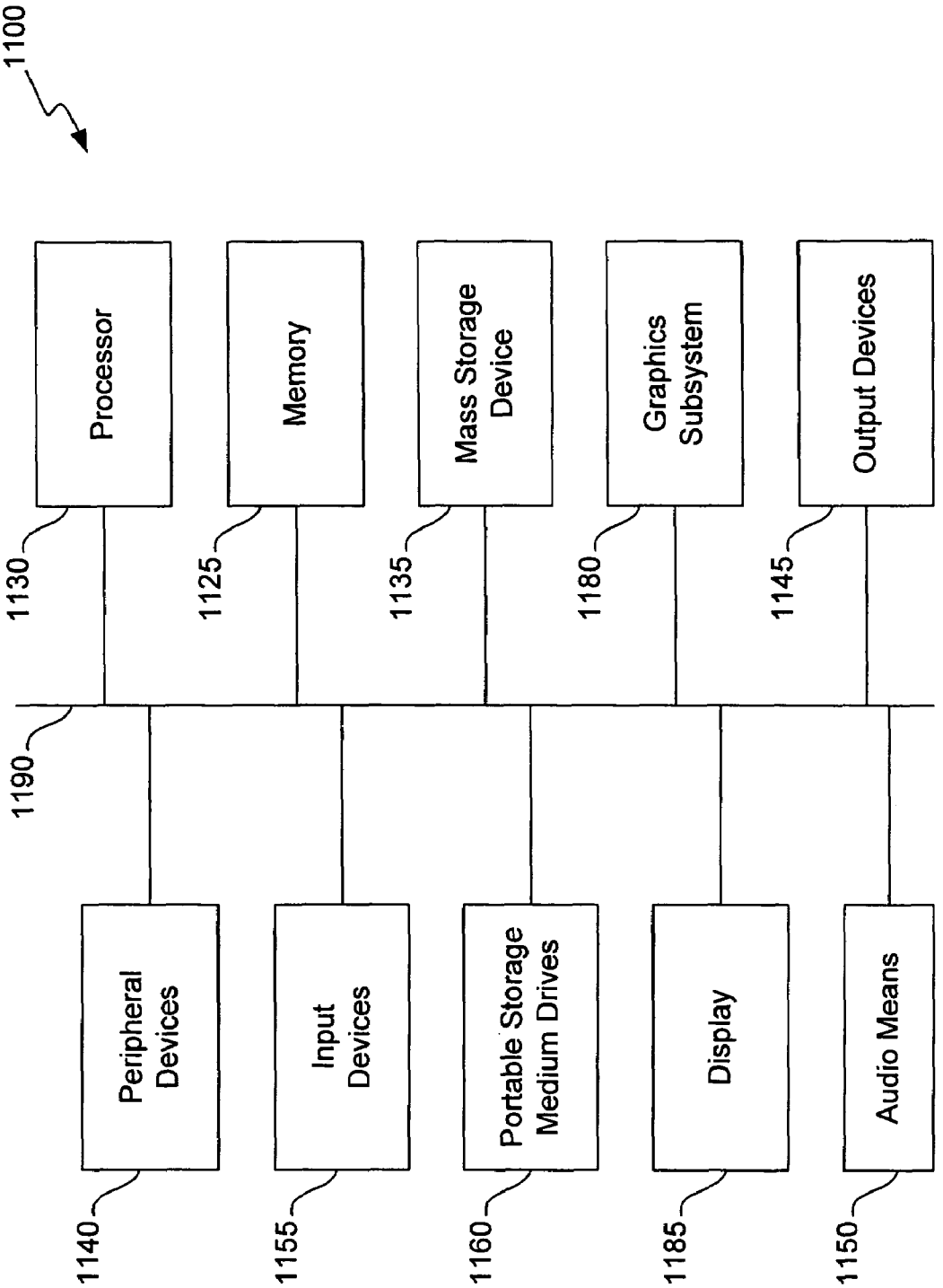
1100
Processor
Memory
Mass Storage Device
Graphics Subsystem
Output Devices
1130
1125
1135
1180
1145
1190
Peripheral Devices
Input Devices
Portable Storage Medium Drives
Display
Audio Means
1140
1155
1160
1185
1150

FIG. 11

METHOD AND SYSTEM FOR CONTROLLING TRANSMISSION OF USB MESSAGES OVER A DATA NETWORK BETWEEN A USB DEVICE AND A PLURALITY OF HOST COMPUTERS

CROSS-REFERENCE TO RELATED APPLICATION

The present application relates to commonly assigned, copending U.S. Patent Application, filed concurrently herewith, for METHOD AND SYSTEM FOR SENDING AND RECEIVING USB MESSAGES OVER A DATA NETWORK Ser. No. 11/006,988. The disclosure of the above-listed application is incorporated herein by reference in its entirety for all purposes.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to transmission of USB messages. More particularly, the present invention relates to controlling the transmission of USB messages over a data network between a USB device and a plurality of host computers.

2. Description of the Related Art

Universal Serial Bus ("USB") has become a standard for connecting peripherals to computers. Most computers have USB ports allowing the connection of USB-enabled peripherals such as mice, keyboards, printers, scanners, digital cameras, webcams, modems, speakers, telephones, storage devices, flash card readers, network interfaces, and other devices. One benefit of USB is that any USB-enabled device ("USB device") can be connected to its host computer using the same, standardized USB connection.

Regardless of the particular USB device, the USB device can be plugged into the host computer simply by connecting a USB cable between the device and the host computer. When the USB device is connected, the operating system of the host computer can often automatically detect it. Driver software can be easily installed on the host computer to interact with the USB device.

For host computers with fewer USB ports than desired USB devices, a USB hub can be connected to provide additional USB connections. Conventional USB hubs, such as a 4-port hub, can be plugged into the USB port on the host computer, enabling the connection of 4 USB devices to the single USB host port. USB hubs can be chained together to provide additional USB ports as desired and share the bandwidth available on the root port.

There are generally four types or modes of data transfer that can occur between the USB device and the computer: (1) Control, (2) Interrupt, (3) Bulk and (4) Isochronous. Control mode is used to enumerate (identify) a device and is often used for out of band device control such as accessing control registers on the device. Interrupt mode can be used for a device such as a mouse or keyboard that sends data at a lower bandwidth and speed. Bulk mode is used for devices such as printers which receive data in larger packets. In one example, a block of data is sent to the printer in 64-byte packets. Isochronous mode is used for streaming devices such as speakers. Data streams between the USB device and the computer.

A USB cable connects a USB device and host computer in a point-to-point manner. The USB cable limits the physical distance and connectivity between a USB device and the host. Individual USB cables are generally manufactured in lengths

on the order of several meters. With USB hubs, USB devices can be connected to a host computer up to about 30 meters away from the host. However, the distance between the USB device and the host it communicates with is still limited to the physical distance of the USB cables and hubs.

Because of the physical limitation of the USB cable, attempts to connect USB devices remotely with respect to a host have been problematic. One example of a USB device which has not been effectively connected to the host as a remote device is a USB-enabled multi-function printer. Print servers exist that use an LPR protocol and provide an Ethernet connection to the printer. However, many print servers preclude the bi-directional protocol of the multi-function printer. The print server only provides the print function of the printer and eliminates the enhanced functions of the printer. Also, when the host computer is connected by virtual private network (VPN) in a corporate environment, the Ethernet enabled printer is not available to print from the host computer. In the past, the only way to access the multiple functions of the printer was to disconnect the printer from the VPN and connect the printer to the host computer by a USB cable. Then, to access the printer via the VPN, the printer had to be disconnected from USB and re-connected to the VPN.

With the advent of multiple hosts, it is desirable to share common peripherals. However, an additional limitation of USB is the inability to share USB devices among two or more hosts. Conventional techniques for connecting USB devices to hosts have only provided for one-to-one connections: one USB device to one host. Logical sharing of USB devices among two or more hosts has not been possible. The only way to arguably share a USB device has been is in the physical sense—the USB cable connecting the USB device to a first host is physically unplugged from the first host, moved into the necessary proximity with a second host, and then plugged into the second host.

What is needed is a scheme for eliminating the physical distance limitation of USB, enabling the remote connection and communication of a USB device with a host, and enabling the sharing of a USB device or devices by multiple hosts.

SUMMARY OF THE INVENTION

Aspects of the present invention relate to methods, computer program products, apparatus, and systems for controlling sending and receiving of universal serial bus ("USB") messages between a plurality of host computers and a USB device over a data network. A first USB server is in communication with a first one of the host computers and the data network. A second USB server is in communication with a second one of the host computers and the data network. A USB client is in communication with the data network and the USB device. A first control path is established between the USB client and the first USB server, and a second control path is established between the USB client and the second USB server. A data transfer path is established between the USB client and the first USB server. The data transfer path enables sending of data between the USB client and the first USB server over the data network. A busy message is sent from the USB client to the second USB server over the second control path when the data transfer path is established with the first USB server.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a block diagram of a system **100** for sending and receiving Universal serial bus ("USB") messages between a host computer and a USB device over a data net-

work, where the USB server is an external device, according to one embodiment of the present invention.

FIG. **2** shows an illustration of a host computer **105** in which a USB server is situated, according to one embodiment of the present invention.

FIG. **3** shows an illustration of a USB device **110** in which a USB client is situated, according to one embodiment of the present invention.

FIG. **4**A shows a block diagram of a USB server **120**, in accordance with one embodiment of the present invention.

FIG. **4**B shows a block diagram of a USB client, in accordance with one embodiment of the present invention.

FIG. **5**A shows a flow diagram of a method **400** performed by USB server for sending a USB message over a data network, performed in accordance with one embodiment of the present invention.

FIG. **5**B shows a flow diagram of a method **500** for translating and communicating a network message as a USB message for a connected computer or USB device, performed in accordance with one embodiment of the present invention.

FIG. **6** shows a block diagram **600** of a plurality of USB Servers capable of interfacing with a USB client over a data network, according to one embodiment of the present invention.

FIG. **7** shows a block diagram **700** of a plurality of USB Servers capable of interfacing with a USB client over a data network, according to one embodiment of the present invention.

FIG. **8** shows a block diagram of apparatus **800** for controlling sending and receiving of USB messages over a data network, according to one embodiment of the present invention.

FIG. **9** shows flow diagram of a method **900** for controlling the sending and receiving of USB messages between a host computer and a USB device over a data network, according to one embodiment of the present invention.

FIGS. **10**A and **10**B show a flow diagram of a method **1000** for controlling the sending and receiving of USB messages between a plurality of host computers and a USB device over a data network, according to one embodiment of the present invention.

FIG. **11** shows a block diagram of a data processing apparatus **1100** such as host computer **105**, used in accordance with embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention enables remote connectivity of USB devices to a host computer or other data processing apparatus, regardless of the operating system on the computer, and regardless of the type of USB device (e.g., camera, printer, keyboard, flash card reader, media player). This host computer or apparatus has full access to a plurality of USB devices served on a data network. One embodiment of methods and apparatus of the present invention provides for a split software spoofing technique to implement a USB ("Universal Serial Bus") system over a data network. The spoofing technique, described below, enables the USB system to appear to include a physical USB connection between a host computer and a USB device, when in fact the USB device is remotely connected to the host computer over the data network. Thus, the physical USB cable requirement and distance limitation associated with conventional USB cables can be eliminated.

One embodiment of methods and apparatus of the present invention further provides for the sharing of hosts or host computers by a remotely connected USB device. In some implementations, bulky or seldom used USB devices can be physically located in designated areas, and connected remotely to one or more host computers over the data network. The terms "host computer" and "host" are used interchangeably herein, generally referring to a computer or other data processing apparatus capable of interacting with a USB server using the methods and apparatus described below.

FIG. **1** shows a system **100** for sending and receiving USB messages between a host, in this case computer **105**, and a USB device **110** over a data network **115**, according to one embodiment of the present invention. In the system **100** of FIG. **1**, the host computer **105** can be a personal computer, workstation or any other data processing apparatus, depending on the desired implementation. The USB device **110** is any device such as a peripheral that communicates using the USB protocol. Examples of USB device **110** include printers, scanners, mice, keyboards, cameras, webcams, multifunction printers, flashcard readers, hard drives, flash drives, and various media players. In FIG. **1**, the data network **115** is any network or combination of networks capable of passing data between elements connected to the data network **115** at network addresses on the data network **115**. Examples of data network **115** include any wired network, wireless network, layer 1, layer 2, layer 3 networks, the Internet, an intranet, an extranet, local area network ("LAN"), wide area network ("WAN"), and any combination thereof.

In FIG. **1**, system **100** further includes a USB server **120** in communication with host computer **105** and data network **115**. The USB server **120** provides translation of messages in a USB protocol to and from network messages, that is, messages formatted in a suitable network protocol for passing over data network **115**. In one embodiment, as shown in FIG. **1**, USB server **120** includes two physical connections. The USB server **120** connects to host computer **105** through a USB port **125** in or connected to the host computer **105**. The USB port **125** is a conventional USB port which interacts with conventional USB driver software in the host computer **105**. The USB server **120** and host computer **105** send USB messages, that is, messages formatted in the USB protocol, between one another through USB port **125**. A second physical connection of USB server **120** is a network connection **130** for sending network messages to and from data network **115**. In one embodiment, as shown in FIG. **1**, the network connection **130** provides an internet protocol ("IP") endpoint or node for USB server **120** on data network **115**. In one example, as shown in FIG. **1**, the network connection **130** includes an Ethernet port which interfaces with Ethernet **135**. For purposes of illustration, in FIG. **1**, Ethernet **135** is shown separate from data network **115**. Those skilled in the art will appreciate that Ethernet **135** can be provided as part of data network **115**.

In FIG. **1**, the system **100** includes a plurality of USB clients **140***a*-**140***d*. Each USB client **140***a*-**140***d* is capable of servicing an associated USB device. For instance, in FIG. **1**, USB client **140***c* is in communication with USB device **110**. Each USB client also interfaces with data network **115** over a suitable network connection for communicating messages between data network **115** and a USB device in communication with that USB client. USB client **140***c* generally has two connections: a USB connection, and a network connection **145**. USB client **140***c* connects to USB device **110** through a USB port. USB client **140***c* connects to data network **115** through the network connection **145** such as an Ethernet port, similar to USB server **120**. The network connection **130** for USB server **120**, and the network connection **145** for USB client **140***c* can be any suitable connection, including LAN/WAN, wireless, wired, and even powerline. USB client **140***c*

provides translation of USB messages to and from network messages and sending such messages between data network **115** and USB device **110**. These functions and additional functions of USB clients are described below.

In FIG. **1**, using techniques described below, USB server **120** appears to host computer **105** as a conventional N-port USB hub. USB Server **120** emulates the interaction of the conventional USB hub with host computer **105**. Conventional USB hub software provided on host computer **105** supports USB protocol and interacts with USB server **120** as if USB server **120** is a conventional USB hub. No additional software or hardware is needed for host computer **105** to interact with USB server **120**. Similarly, each USB client **140***a*-**140***d* can interface with a USB device such as device **110** using a conventional USB port. The USB client **140***c* appears to USB device **110** as one output or output port of a conventional USB hub. No additional software or hardware is required for USB device **110** to interact with USB client **140***c*.

In FIG. **1**, the plurality of USB clients **140***a*-**140***d* are associated with the single USB server **120**. In another embodiment of the present invention, there are a plurality of host computers such as host computer **105**, and a plurality of USB servers such as USB server **120**. Each host computer is in communication with a respective one of the USB servers. There are also a plurality of USB devices, such as multi-function printers, each of which has an associated USB client. The USB servers and USB clients are connected to network **115** in the same manner as USB server **120** and USB client **140***c*, as illustrated in FIG. **1**. In this embodiment, any combination of the USB clients can be associated with any combination of the USB servers. For example, ten printers connected to respective USB clients can be associated with a single personal computer (PC). Then a virtual unplug operation, that is, re-association, can be performed so that five of the ten printers are associated with a first PC and USB server pair, and the remaining five printers are associated with a second PC and second USB server. This virtual unplug operation can be performed dynamically so that any one of the USB clients can be re-associated with any one of the USB servers. When such a re-association is performed, the computer **105** receives a "connect" and "disconnect" message from the USB server **120** as if the USB devices were physically plugged or unplugged into the USB port **125**.

In one embodiment of the system **100** of FIG. **1**, USB server **120** generally does not need a power supply independent of that provided by USB port **125**. That is, the host computer **105** can power USB server **120** through the USB port **125**. In one embodiment, as the host computer **105** is powering the USB server, the host computer **105** will limit the power it serves through the USB server to the USB devices (100 mA). In another embodiment, the USB server is self powered allowing the USB Device **110** the full amount of power available on a hub port (500 mA). In a third embodiment, the USB server manipulates the USB device **110**'s power requirement messages to state the device is fully self powered and needs no power through the bus.

Embodiments of the present invention provide for different implementations of USB server **120** and USB clients such as USB client **140***c*. In one embodiment, as shown in FIG. **1**, USB server **120** is external to host computer **105**. In this embodiment, USB server **120** includes software configured to provide the functions described below, and hardware needed to carry out these functions and to provide physical connections to host computer **105** and data network **115**. Similarly, in the embodiment shown in FIG. **1**, USB client **140***c* is situated external to USB device **110** and incorporates software and hardware to provide the functions of USB client **140***c* and the necessary physical connections to data network **115** and USB device **110**.

In an alternative embodiment shown in FIG. **2**, USB server **120** is situated within host computer **105**. In this embodiment, USB server **120** connects to a network interface **205** provided within host computer **105** for connecting to data network **115**. Thus, in the embodiment of FIG. **2**, USB server **120** does not need its own external physical connection for connecting to data network **115**. In the embodiment of FIG. **2**, USB server **120** can be implemented primarily in software to perform the same functions provided by USB server **120** in FIG. **1**.

FIG. **3** shows an alternative implementation of USB client **140***c* to that shown in the system **100** of FIG. **1**. In FIG. **3**, similar to the implementation of USB server **120** in FIG. **2**, USB client **140***c* is situated within USB device **110**. USB client **140***c* communicates with data network **115** through a network interface **305** provided by USB device **305**. Thus, as with USB server **120** in FIG. **2**, USB client **140***c* does not require its own external physical connection to data network **115**. USB client **140***c* essentially piggybacks on the functionality provided by network interface **305** to interact with data network **115**. In the embodiment of FIG. **3**, USB client **140***c* can be implemented primarily in software on the USB device **110**. This software implementation can be beneficial in circumstances where there are size and space constraints on USB client **140***c*.

In FIGS. **2** and **3**, because USB server **120** and USB client **140***c* are implemented primarily in software, on the respective host computer **105** and USB device **110**, the USB server **120** and USB client **140***c* can be characterized as "logical" or "virtual" implementations. On the other hand, in one implementation of the embodiment shown in FIG. **1**, the USB server **120** and USB client **140***d* include hardware to carry out the respective functions and provide the necessary physical connections for USB server **120** and USB client **140***d*. In this predominantly hardware implementation, USB server **120** and USB client **140***d* can be characterized as "physical" devices. The virtual implementation is more cost effective and raises the shareable bus bandwidth when the physical medium's (e.g. Gigabit Ethernet) bandwidth is greater than the USB bus. The physical implementation provides host computer **105** operating system independence and USB client **140***d* compatibility to various USB devices.

FIG. **4**A shows a block diagram of a USB server **120**, in accordance with one embodiment of the present invention. The USB server **120** includes apparatus to generally perform at least four functions. First, the USB server **120** includes an IP interface module **325** which enables USB server **120** to be an IP client of data network **115**. The IP interface module **325** provides an IP address for USB server **120** so that USB server **120** can send and receive messages as IP packets or other formats suitable for sending over data network **115**. The IP connection established between IP interface module **325** and data network **115** can be established with any suitable form of wired or wireless IP connectivity such as RG-45, power line, 802.11 in all forms, and conventional Ethernet connectivity.

Secondly, in FIG. **4**A, USB server **120** further includes a USB interface module **330** which interfaces and interacts with host computer **105** through USB port **125**, providing the USB hub emulation described above. USB interface module **330** is configured to implement the appropriate USB hub device protocol capabilities. The third function of USB server **120** is a implemented in a translation module **335** which, in one embodiment, provides USB over IP protocol. The translation module **335** is generally configured to translate USB messages to network messages (e.g., IP packets) for sending

USB messages received from host computer **105** as network messages over data network **115**, as explained below. Similarly, translation module **335** is configured to translate network messages received from data network **115** to USB format for delivery to host computer **105** through USB port **125**.

Fourth, in FIG. **4**A, the USB server **120** includes an association module **340** configured to establish and maintain an association between the USB server **120** and zero or more USB clients. Association module **340** can establish the associations using a table, TCP sockets, a web interface provided to a user of host computer **105** allowing the user to select clients to associate with, and other techniques. In one embodiment, association module **340** manages the associations between the USB server **120** and corresponding USB clients in the form of a list **345** stored in memory or a processor readable storage medium accessible by association module **340**. The associations can be established during power-on, using data stored in flash memory, dynamically by discovery mechanisms to identify USB servers on the network **115**, using configurations managed by the user, using a token scheme, or with any other mechanism using an agreed-upon sequence of events.

FIG. **4**B shows a block diagram of a USB client, in accordance with one embodiment of the present invention. The USB client has similar functionality as USB server **120**. For instance, the USB client includes an IP interface module **350**, providing the same functionality that IP interface module **325** provides for USB server **120**. A USB host module **355** interfaces and interacts with a USB device **110**, using USB protocol. The USB host module **355** implements the "host" side of USB protocol. Thus, the USB host module **355** can recognize USB devices when those devices are connected to the USB client. The USB host module **355** can send interrogation messages to the USB device to determine attributes of the USB device. Then the USB host module **355** will configure and enable the USB device **110**.

In FIG. **4**B, the USB client further includes a translation module **360**, similar to translation module **335** in USB server **120**. Here, the translation module **360** is configured to translate USB messages to network messages (e.g., IP packets) for sending USB messages received from USB device **110** as network messages over data network **115**, and translate network messages received from data network **115** to USB format for delivery to USB device **110**. In addition, the USB client includes an association module **365** which is generally configured to establish an association with zero or one USB server at a time, such as USB server **120**. The association module **365** can select the USB server to associate with using any number of methods, including: (1) broadcast to find the nearest USB server, (2) stored data identifying a particular USB server, (3) a web page or other user interface allowing selection of the USB server, and (4) hardware settings allowing a user to choose the USB server.

In one embodiment, as shown in FIG. **4**B, the USB client also includes a power supply **370** which can supply power to the connected USB device. In an alternative embodiment, the USB client does not include power supply **370**.

Those skilled in the art will appreciate that the apparatus, modules and functions described above can be implemented with combinations of hardware and software. In one example, the USB server **120** includes a processor and a memory with instructions executable to perform the functions above. Similarly, the USB client can also have a processor and memory for performing its functions. Other hardware and software implementations of the USB server **120** and USB client are possible, as will be understood by those skilled in the art.

The system **100** of FIG. **1** provides for sending and receiving USB messages between host computer **105** and USB devices such as USB device **110**. The USB server **120** and USB client **140***c* cooperate to translate messages between USB protocol or format and a network format suitable for sending over data network **115**. The USB server **120** and USB client **140***b* provide for receiving a USB message at USB client **140***c* from USB device **110**, translating the USB message to packets formatted for sending over the data network **115**, that is, a network message. The USB server **120** receives the network message and translates the message back to the original USB format and provides the USB message to host computer **105** over USB port **125**. These functionalities of USB client **140***c* and USB server **120** are reversed when host computer **105** sends a USB message to USB device **110** over data network **115**.

FIG. **5**A shows a method **400** performed by USB server **120** when sending a USB message from host computer **105** to USB client **140***c* over data network **115**. The method **400** is also performed by USB client **140***c* for sending a USB message originating from USB device **110** to USB server **120** over data network **115**.

In FIG. **5**A, a USB message is received from the host computer **105** or USB device **110**. "USB message" generally refers to a message in the USB protocol. When the USB message is received by the USB server **120** or USB client **140***c*, in Step **410**, the server **120** or client **140***c* translates the USB message to a network message, that is, a message in a suitable protocol or format for sending over data network **115**. Suitable protocols for the network message include layer 2, layer 3, layer 4 and the other protocols appropriate for passing the network message over any of the implementations of data network **115** described above. In one embodiment, the USB message, a layer 2 protocol, is encapsulated in an appropriate higher layer protocol, such as layer 3 or layer 4, during the translation step **410**. Such an encapsulation operation is generally known to those skilled in the art. In Step **415**, the USB server **120** or USB client **140***c* sends the network message over data network **115** to the USB client **140***c* or USB server **120**.

FIG. **5**B shows a method **500** performed by USB server **120** or USB client **140***c* for communicating a network message received over data network **115** to host computer **105** or USB device **110** as a USB message. In Step **505**, when the network message is received from data network **115**, the USB server **120** or USB client **140***c* translates the network message back to the USB format. Because the original USB message was encapsulated in the appropriate network protocol, as described above in FIG. **5**A, the network message is essentially de-encapsulated back to its original USB protocol. In Step **515**, the USB message can then be provided to the host computer **105** or USB device **110** over a USB port or connection, and properly interpreted by the receiving device.

FIG. **6** shows a block diagram of USB server **120** and USB client **140***c* in communication with data network **115**, according to one embodiment of the present invention. In addition, system **600** includes USB server **605** connected between data network **115** and a second host computer **615**, and USB server **610** connected between data network **115** and a third host computer **620**. In the embodiment shown in FIG. **6**, USB client **140***c* is capable of servicing the various USB servers **120**, **605**, **610**. In one embodiment, USB client **140***c* generally maintains a one-to-one relationship with its corresponding USB server. For instance, in FIG. **1**, USB client **140***c* has a one-to-one relationship with USB server **120**. That is, the USB client **140***c* associates with the single USB server **120** and establishes a connection therewith to send encapsulated

USB messages between the USB client **140***c* and USB server **120** over data network **115**. In the embodiment of FIG. **6**, USB client **140***c* can associate with the multiple USB servers **120**, **605**, **610**, although USB client **140***c* generally transfers data to the servers one-at-a-time, as explained below. In the system **600**, the various USB servers **120**, **605**, **610** can function as multiple hosts for the single USB client **140***c*. Methods and apparatus provided in USB client **140***c* provide the capability of serving multiple hosts, as explained below.

FIG. **7** shows a block diagram of a system **700** in which communications paths are established between USB client **140***c* and the various USB servers over data network **115**. In one embodiment, the communications paths include control paths **705**, **710**, **715** established between USB client **140***c* and the respective USB servers **120**, **605**, **610**. The communications paths further include a data transfer path **720** which can be established between USB client **140***c* and USB server **120**. Data transfer paths can also be established between USB client **140***c* and the other USB servers **605**, **610**. Those skilled in the art should appreciate that the various paths shown in FIG. **7** can be established independent of one another, and at various times during the sending and receiving of messages, as desired for the particular implementation. Generally, data transfer paths are established between USB client **140***c* and one USB server at a time, as explained below. Those skilled in the art should also appreciate that the various control paths and data transfer path shown in FIG. **7** can be combined or further divided as desired, depending on the particular implementation.

In one embodiment, described with reference to FIG. **7**, the functionalities of the various control paths and data transfer path are provided by the USB protocol. Generally, using the USB protocol, network traffic can be segmented into three categories. The first provides for USB connection and enumeration commands, such as device discovery information including information indicating whether a device is present, the type of the device, and the status of the device, e.g., connected or disconnected. The second provides for data control messages such as NACK and STALL that provide feedback to hosts such as the USB servers when a receiving device such as USB client **140***c* cannot receive or handle a command or other message sent to the receiving device. The third category includes data messages that contain the content sent to or from the device. Under the USB protocol, generally the data control messages on a path separate from the data path or data transfer path. In FIG. **7**, for purposes of simplification, the control paths **705**, **710**, **715** provide receiving and sending of the first two categories of USB messages, that is, USB connection and enumeration commands, as well as data control messages such as NACK and ACK over the appropriate endpoints. The data transfer path **720** provides sending and receiving of data such as the network messages described herein. In one embodiment, different network characteristics are applied to each of the paths. For example, a data control message can have higher network priority than bulk datagrams.

In FIG. **7**, generally when USB client **140***c* boots up or is otherwise enabled, the USB client **140***c* searches for and associates with one of the USB servers **120**, **605**, **610**. When the association is made, control messages are sent between the USB server and USB client over the control path between the two devices. Data, such as a network message containing an encapsulated USB message, is sent over data transfer path **720**. The network messages are generally packetized in a suitable format or protocol for sending over the data network **115** between the associated USB client **140***c* and USB server **120**. When USB client **140***c* establishes a data transfer path with one of the USB servers, in FIG. **7**, USB server **120**, the other USB servers **605**, **610** must generally wait until USB client **140***c* terminates data transfer path **720** and then establishes a data transfer path with one of the other servers **120**, **610**.

FIG. **8** shows a block diagram **800** of a system for controlling sending and receiving of USB messages over data network **115**, using USB server **120** and USB client **140***c*. The USB server **120** is associated with a host computer such as host computer **105** of FIG. **1**. The USB client **140***c* is associated with a USB device **110**, as shown in FIG. **1**. In FIG. **8**, USB server **120** includes a client SW **805** an USB system SW **810**, provided as standard USB architecture. The functionality of modules **805** and **810** and other USB architecture is described in the Universal Serial Bus Specification, Revision 2.0, Apr. 27, 2000, incorporated herein by reference in its entirety.

In FIG. **8**, USB server **120** includes a USB host controller **815** which interfaces with any and all USB device drivers on host computer **105** serviced by USB server **120**. The USB host adapter **820** is configured to receive network messages from the data network, receive USB messages from the host computer, and translate between USB protocol and network protocol as described above in methods **400** and **500** to pass the various messages to their destinations. In one embodiment, USB host adapter **820** is divided into a receiving part which is configured to receive USB messages and network messages, and a translating part configured to translate messages from one protocol to another. The USB host adapter **820** is further configured to send network messages over the data network to USB client **140***c* for subsequent translation back to USB protocol for the connected USB device **110**.

In FIG. **8**, a message queue **825** situated in USB server **120** interfaces with control path **710** of FIG. **7** to provide a buffer for sending control messages, e.g., "ACK," "NACK," and "PING," as described in the USB 2.0 specification. In FIG. **8**, a stream queue **830** provides a buffer and interface with data transfer path **720** in FIG. **7** for streaming data such as network messages to and from data network **115** for later translation to a USB protocol for host computer **105** or USB device **110**. Those skilled in the art should appreciate that different types of streaming can be set up and enabled through stream queue **830** depending on the desired type of data transfer between USB server **120** and USB client **140***c* over data network **115**, e.g., bulk, isochronous, etc. The stream queue **830** and message queue **825** can be used to adjust for network jitter during a USB transmission. In one implementation, two separate TCP/IP sockets are provided by network connection **130** between USB server **120** and data network **115**. One TCP/IP socket is provided for message queue **825** to send data over control path **710**, of FIG. **7**. The second TCP/IP socket is used for stream queue **830** to send data over data transfer path **720**.

In USB server **120** of FIG. **8**, local host buffer **835** provides an optional memory buffer to be used on USB server **120** to cache data during data transfer or when waiting for a remote device such as USB client **140***c* to be ready to receive data over data transfer path **720**.

In FIG. **8**, USB client **140***c* includes a USB logical device **840** and USB bus interface **845**, provided as part of the standard USB architecture, as described in the USB 2.0 specification. In addition, USB client **140***c* includes USB device adapter **850** which provides the translation of USB messages to network messages and vice versa, as explained above in methods **400** and **500**. A stream queue **855** and message queue **860** are also provided in USB client device **140**. The stream queue **855** and message queue **860** provide essentially the same functions as the counterpart stream queue **830** and

message queue **825** in USB server **120**. In USB client **140***c*, a multi-host controller **865** manages network traffic to and from USB client **140***c*. That is, multi-host controller **865** signals to connected hosts such as USB server **120** and other USB servers **605** and **610** the current status of USB device **110**. Multi-host controller **865** manages the establishing and termination of communications paths with the respective USB servers over data network **115**, as illustrated in FIG. **7** and explained below. In one embodiment, multi-host controller **865** maintains a table of TCP port and remote host IP addresses, as well as an indication of which host or USB server is "active" so that any request message from other "inactive" hosts is sent a "busy" message such as a NACK or PING, as provided by the USB protocol. In addition, multi-host controller **865** acts as a host for USB device **110** and controls the physical initialization of device **110**.

The system **800** shown in FIG. **8** provides "spoofing" components in the form of USB host adapter **820** and USB device adapter **850**. USB host adapter **820** interfaces and interacts with host computer **105** in a manner that host computer **105** would be connected and engaged with a conventional USB hub. That is, USB host adapter **820** responds to and sends signals to host computer **105** over USB port **125**, at times mimicking a USB hub, as if USB device **110** was connected directly to the USB hub or the USB server **120**. Similarly, USB device adapter **850** in USB client **140***c* interact with USB device **110** as if USB device **110** was interacting with the output of a USB hub or USB port connected to host computer **105**. Thus, no additional driver software or other functions are required to be implemented in USB device **110** and host computer **105** to interact with USB server **120** and associated USB clients and attain the benefits provided by the USB server and USB client pair.

FIG. **9** shows a method **900** for controlling the sending and receiving of USB messages between host computer **105** and USB device **110** over data network **115**. The method **900** is described with reference to FIGS. **1** and **7**. In Step **905**, host computer **105** sends a "SETUP" message to host adapter **820** in USB server **120**. When the SETUP message is received by host adapter **820**, in Step **910**, host adapter **820** sends a "SETUP-IP" as a request message to multi-host controller **865** and USB client **140***c*. A control path is established between host adapter **820** and multi-host controller **865** for sending control messages such as the SETUP-IP message. The control path can be established before or after the SETUP-IP message is sent, depending on the desired implementation. Those skilled in the art will appreciate that, when the control path has not yet been established, the SETUP-IP message is sent over an alternative communications path over data network **115** between the USB server **120** and USB client **140***c*.

In FIG. **9**, in Step **915**, multi-host controller **865** passes a SETUP message to USB device **110**. In this example, USB device **110** is available to receive data, so in step **920**, multi-host controller **865** sends an acknowledge message such as "ACK-IP/SETUP" back to host adapter **820**. The data transfer path **720** is then established between USB server **120** and USB client **140***c*. In an alternative embodiment, data transfer path **720** has already been established. In Step **925**, an "OUT" message including data in a USB protocol is sent from host computer **105** to host adapter **820**. USB host adapter **820** encapsulates the USB message in a format suitable for sending over data network **115**, and sends the encapsulated message as a network message or "OUT-IP" message in Step **930** to multi-host controller **865** in USB client **140***c*. In Step **935**, the network message is translated back to USB protocol by USB device adapter **850** and passed on to USB device **110**. In Step **940**, when the data transfer is successful over the data transfer path **720**, the multi-host controller **865** sends an acknowledge message such as "ACK-IP/OUT" back to host adapter **820** and USB server **120**. In Step **945**, an acknowledge or "ACK" message is accordingly provided to host computer **105**.

FIGS. **10**A and **10**B show a method for controlling sending and receiving of USB messages between a plurality of host computers and a single USB device **110** over data network **115**, performed in accordance with one embodiment of the present invention. In this example, as shown in FIG. **7**, a first control path **705** is established between USB client **140***c* and USB server **120** ("USB server A"). A second control path **710** is established between USB client **140***c* and USB server **605** ("USB server B"). As mentioned above, these control paths **705**, **710** can be established at the outset of processing, or during processing as needed to send control messages between the various devices. In FIG. **10**A, Steps **905-935**, as described above with respect to FIG. **9**, are performed between USB server **120** with associated host computer **105** and USB client **140***c* with associated USB device **110**.

In FIG. **10**A, when the data transfer path is still established between USB server A and USB client **140***c*, in Step **1005**, a host computer B associated with USB server B sends a "SETUP" message to USB server B. USB server B, in Step **1010**, then sends a request or "SETUP-IP" message to multi-host controller **865**. Because the data transfer path **720** is still established with USB server A, in Step **1015**, multi-host controller **865** sends a busy message back to USB server B, indicating that USB client **140***c* is not yet available to establish a data transfer path or otherwise receive data from USB server B on behalf of host computer B. In one embodiment, this busy message is in the form of a "NACK-IP/setup" message, provided by both the USB 1.1 and 2.0 protocols. Another suitable busy message is a "PING" message provided by the PING function of the USB 2.0 protocol for sending data to high speed devices.

In FIG. **10**A, when data transfer has been completed between USB server A and USB client **140***c*, a complete message or other suitable acknowledge message, such as "ACK-IP/Out" is sent by multi-host controller **865** back to USB host adapter **820** in USB server A, in Step **1020**. This complete message can then be passed, in Step **1025**, to host computer A as an "ACK" message. The USB host adapter **820** in USB server **120** can then terminate the data transfer path **720** established between USB server A and USB client **140***c*, responsive to this complete message.

In FIG. **10**B, in another embodiment, a complete message **1030** is sent from host computer A to USB server A, when data transfer is complete. The USB server A sends a "complete-IP" message or other suitable message to multi-host controller **865** in USB client **140***c*, in Step **1035**, indicating that the data transfer is complete. This complete message can then be passed to USB device **110** in Step **1040**. A further complete message, such as "ACK-IP/complete" can then be sent from multi-host controller **865** to host adapter **820** in Step **1045**. Responsive to any of the various complete messages sent in Steps **1030-1045**, the data transfer path **720** between USB server A and USB client **140***c* is then terminated.

In FIG. **10**B, when data transfer path **720** has been terminated, USB client **140***c* is available to establish a data transfer path with another one of the USB servers **120**, **605**, **610** in FIG. **7**. In one embodiment, shown in FIG. **10**B, an acknowledge message, such as "ACK-IP/setup" message **1055** is sent from multi-host controller **865** back to USB server B, which received the busy message in Step **1015**. Then, Steps **1060-1090** can be performed between host computer B, USB server

B, multi-host controller **865**, and USB device **110**, identical to Steps **930**, **935**, and **1030-1050** between host computer A, USB server A, USB client **140***c*, and USB device **110**, described above. Again, when the data transfer path is established between USB client **140***c* and USB server B, requests for data transfer or for the establishing of data transfer paths from any of the other USB servers will be replied to with a busy message such as a "NACK" or "PING" message, as shown in FIG. **7**. Thus, USB client **140***c* acts as a gatekeeper for USB device **110** by providing for data transfer with one host at a time. Those skilled in the art should appreciate that interleaving transfers will be applicable for some devices, but not all. With some devices and host computer class drivers, data transfer will involve transaction interleaving (set of multi-transfers, rather than USB interleaving). In other instances, there will be no interleaving.

FIG. **11** is a block diagram of a host computer **105** or other data processing apparatus **1100** used as described herein. The computer system **1100** includes a processor **1130** for executing program instructions stored in a memory **1125**. In some embodiments, processor **1130** includes a single microprocessor, while in others, processor **1130** includes a plurality of microprocessors to define a multi-processor system. In some embodiments, the memory **1125** stores instructions and data for execution by processor **1130**, including instructions and data for performing the methods described above. Depending on the extent of software implementation in computer system **1100**, the memory **1125** stores executable code when in operation. The memory **1125** includes, for example, banks of read-only memory (ROM), dynamic random access memory (DRAM) as well as high-speed cache memory.

In FIG. **11**, within computer system **1100**, an operating system comprises program instruction sequences. The operating system provides a software platform upon which application programs may execute, in a manner readily understood by those skilled in the art. In some embodiments, the computer system **1100** further comprises one or more applications having program instruction sequences for performing the methods described above.

In FIG. **11**, the computer system **1100** incorporates any combination of additional devices. These include, but are not limited to, a mass storage device **1135**, one or more peripheral devices **1140**, an audio means **1150**, one or more input devices **1155**, one or more portable storage medium drives **1160**, a graphics subsystem **1180**, a display **1185**, and one or more output devices **1145**. The various components are connected via an appropriate bus **1190** as known by those skilled in the art. In alternative embodiments, the components are connected through other communications media known in the art. In one example, processor **1130** and memory **1125** are connected via a local microprocessor bus; while mass storage device **1135**, peripheral devices **1140**, portable storage medium drives **1160**, and graphics subsystem **1180** are connected via one or more input/output buses.

In FIG. **11**, mass storage device **1135** is implemented as fixed and/or removable media, for example, as a magnetic, optical, or magneto-optical disk drive. The drive is preferably a non-volatile storage device for storing data and instructions for use by processor **1130**. In some embodiments, mass storage device **1135** stores client and server information, code for carrying out methods in accordance with exemplary embodiments of the invention, and computer instructions for processor **1130**. In other embodiments, computer instructions for performing methods in accordance with exemplary embodiments of the invention also are stored in processor **1130**. The computer instructions are programmed in a suitable language such as Java or C++.

In FIG. **11**, the portable storage medium drive **1160**, in some embodiments, operates in conjunction with a portable non-volatile storage medium, such as a floppy disk, CD-ROM, or other computer-readable medium, to input and output data and code to and from the computer system **1100**. In some embodiments, methods performed in accordance with exemplary embodiments of the invention are implemented using computer instructions that are stored on such a portable medium and input to the computer system **1100** via portable storage medium drive **1160**.

In FIG. **11**, the peripheral devices **1140** include any type of computer support device, such as an input/output (I/O) interface, to add functionality to computer system **1100**. In one example, the peripheral devices include a network interface card for interfacing to a network, a modem, and the like. The peripheral devices also include input devices to provide a portion of a user interface and may include an alphanumeric keypad or a pointing device such as a mouse, a trackball, a stylus, or cursor direction keys. The I/O interface comprises conventional circuitry for controlling input devices and performing particular signal conversions upon I/O data. The I/O interface may include, for example, a keyboard controller, a serial port controller, and/or digital signal processing circuitry.

In FIG. **11**, the graphics subsystem **1180** and the display **1185** provide output alternatives of the system. The graphics subsystem **1180** and display **1185** include conventional circuitry for operating upon and outputting data to be displayed, where such circuitry preferably includes a graphics processor, a frame buffer, and display driving circuitry. The display **1185** may include a cathode ray tube (CRT) display, a liquid crystal display (LCD), or other suitable devices. The display **1185** preferably can display at least 256 colors. The graphics subsystem **1180** receives textual and graphical information and processes the information for output to the display **1185**, often as a GUI. A video card in the computer system **1100** also comprises a part of graphics subsystem **1180** and also preferably supports at least 256 colors. For optimal results in viewing digital images, the user should use a video card and monitor that can display the True Color (24 bit color) setting. This setting enables the user to view digital images with photographic image quality.

In FIG. **11**, audio means **1150** preferably includes a sound card that receives audio signals from a peripheral microphone. In addition, audio means **1150** may include a processor for processing sound. The signals can be processed by the processor in audio means **1150** of computer system **1100** and passed to other devices as, for example, streaming audio signals.

In some embodiments, programs for performing methods in accordance with exemplary embodiments of the invention are embodied as computer program products. These generally include a storage medium or media having instructions stored thereon used to program a computer to perform the methods described above. Examples of suitable storage medium or media include any type of disk including floppy disks, optical disks, DVDs, CD ROMs, magnetic optical disks, RAMs, EPROMs, EEPROMs, magnetic or optical cards, hard disk, flash card, smart card, and other media.

Stored on one or more of the computer readable media, the program includes software for controlling both the hardware of a general purpose or specialized computer or microprocessor. This software also enables the computer or microprocessor to interact with a human or other mechanism utilizing the results of exemplary embodiments of the invention. Such software includes, but is not limited to, device drivers, oper-

ating systems and user applications. Preferably, such computer readable media further include software for performing the methods described above.

In certain other embodiments, a program for performing an exemplary method of the invention or an aspect thereof is situated on a carrier wave such as an electronic signal transferred over a data network. Suitable networks include the Internet, a frame relay network, an ATM network, a wide area network (WAN), or a local area network (LAN). Those skilled in the art will recognize that merely transferring the program over the network, rather than executing the program on a computer system or other device, does not avoid the scope of the invention.

Embodiments of the invention, including the methods, apparatus, modules, adaptors, controllers, and functions described herein, can be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. For example, the USB server **120** can be constructed to include a processor, memory, and appropriate software for performing the methods and functions described above. The same is true for any of the USB clients. Apparatus embodiments of the invention can be implemented in a computer program product tangibly embodied in a machine-readable storage device for execution by a programmable processor; and method steps of the invention can be performed by a programmable processor executing a program of instructions to perform functions of the invention by operating on input data and generating output. Embodiments of the invention can be implemented advantageously in one or more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and instructions from, and to transmit data and instructions to, a data storage system, at least one input device, and at least one output device. Each computer program can be implemented in a high-level procedural or object-oriented programming language, or in assembly or machine language if desired; and in any case, the language can be a compiled or interpreted language.

Although illustrative embodiments and applications of this invention are shown and described herein, many variations and modifications are possible which remain within the concept, scope, and spirit of the invention, and these variations would become clear to those of ordinary skill in the art after perusal of this application. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.

We claim:

1. A method for controlling sending and receiving of universal serial bus ("USB") messages between a plurality of host computers and a USB device over an Ethernet data network, a first USB server in communication with a first one of the host computers and the Ethernet data network, a second USB server in communication with a second one of the host computers and the Ethernet data network, a USB client in communication with the Ethernet data network and the USB device, the method comprising the steps of:

establishing a first control path between the USB client and the first USB server and a second control path between the USB client and the second USB server;

configuring an association module in the USB client with a first association between the USB client and the first USB server and a second association between the USB client and the second USB server;

establishing a first data transfer path between the USB client and the first USB server, the first data transfer path enabling sending of data between the USB client and the first USB server over the Ethernet data network; and

sending a busy message from the USB client to the second USB server over the second control path when the first data transfer path is established with the first USB server.

2. The method of claim **1**, wherein the step of establishing the first data transfer path between the USB client and the first USB server includes:

sending a request message from the first USB server to the USB client over the first control path.

3. The method of claim **1**, wherein the step of establishing the first data transfer path between the USB client and the first USB server includes:

sending an acknowledge message from the USB client to the first USB server over the first control path.

4. The method of claim **1**, further comprising the step of:

sending a request message from the second USB server to the USB client over the second control path, the busy message being sent responsive to the request message.

5. The method of claim **1**, further comprising the steps of:

terminating the first data transfer path; and

establishing a second data transfer path between the USB client and the second USB server, the second data transfer path enabling sending of data between the USB client and the second USB server over the data network.

6. The method of claim **5**, wherein the step of terminating the first data transfer path includes:

sending a complete message from the USB client to the first USB server over the first control path.

7. The method of claim **5**, wherein the step of terminating the first data transfer path includes:

sending a complete message from the first USB server to the USB client over the first control path.

8. The method of claim **5**, wherein the step of establishing the second data transfer path between the USB client and the second USB server includes:

sending an acknowledge message from the USB client to the second USB server over the second control path.

9. The method of claim **5**, further comprising the step of:

sending the busy message from the USB client to the first USB server over the first control path when the second data transfer path is established with the second USB server.

10. The method of claim **5**, further comprising the step of:

sending the busy message from the USB client to a third USB server over a third control path established between the USB client and the third USB server when the second data transfer path is established with the second USB server, the third USB server in communication with a third one of the host computers and the data network.

11. The method of claim **1**, wherein the USB client is connected to a single USB device.

12. The method of claim **1**, further comprising:

finding a first USB server and a second USB server with which the USB client should associate.

13. The method of claim **12**, wherein the finding includes:

broadcasting to find the nearest USB server.

14. The method of claim **12**, wherein the finding includes:

retrieving stored data identifying a particular USB server with which the USB client should associate.

15. The method of claim **12**, wherein the finding includes:

receiving an identification of a USB server from a user in response to presenting the user with a user interface allowing selection of the USB server.

16. The method of claim 12, wherein the finding includes:
receiving a selection of a USB server from a user through hardware settings.

17. A computer program product, stored on a processor readable medium, comprising instructions operable to cause a data processing apparatus to perform a method for controlling sending and receiving of universal serial bus ("USB") messages between a plurality of host computers and a USB device over an Ethernet data network, a first USB server in communication with a first one of the host computers and the Ethernet data network, a second USB server in communication with a second one of the host computers and the Ethernet data network, a USB client in communication with the Ethernet data network and the USB device, the method comprising the steps of:
establishing a first control path between the USB client and the first USB server and a second control path between the USB client and the second USB server;
configuring an association module in the USB client with a first association between the USB client and the first USB server and a second association between the USB client and the second USB server;
establishing a first data transfer path between the USB client and the first USB server, the first data transfer path enabling sending of data between the USB client and the first USB server over the Ethernet data network; and
sending a busy message from the USB client to the second USB server over the second control path when the first data transfer path is established with the first USB server.

18. The computer program product of claim 17, wherein the USB client is connected to a single USB device.

19. A system for controlling sending and receiving of universal serial bus ("USB") messages between a plurality of host computers and a USB device over a data network, the system comprising:
a data network that comprises at least one of the Internet, an intranet, an extranet, a local area network, a wide area network, or a combination thereof;
a first USB server in communication with the data network and a first one of the host computers, the first USB server having a first network address on the data network;
a second USB server in communication with the data network and a second one of the host computers, the second USB server having a second network address on the data network; and
a USB client in communication with the data network and the USB device, the USB client configured to:
i) establish communications paths with the first and second USB servers,
ii) configure an association module in the USB client with a first association between the USB client and the first USB server and a second association between the USB client and the second USB server;
iii) establish a data transfer path with the first USB server, the data transfer path enabling passing data between the USB client and the first USB server over the data network, and
iv) send a busy message to the second USB server over the communications path established with the second USB server when the data transfer path is established with the first USB server.

20. The system of claim 19, wherein the USB client sends the busy message to the second computer responsive to a request message received from the second computer over the communications path established with the second computer.

21. The system of claim 19, the USB client further configured to:
iv) receive a USB message from the USB device, and
v) translate the USB message to a network format suitable for sending over the data network.

22. The system of claim 21, wherein translating the USB message to the network format includes encapsulating the USB message in a network protocol.

23. The system of claim 21, the USB client further configured to:
vi) send the translated USB message as a network message to the first USB server over the data transfer path.

24. The system of claim 19, the USB client further configured to:
iv) receive a network message from the first USB server over the data transfer path,
v) translate the network message to a USB format, and
vi) provide the translated network message as a USB message for the USB device.

25. The system of claim 19, wherein the data network includes an Internet.

26. The system of claim 19, wherein the data network includes a wireless network.

27. The system of claim 19, wherein the USB client is connected to a single USB device.

28. A system for controlling sending and receiving of universal serial bus ("USB") messages between a plurality of host computers and a USB device over an Ethernet data network, the system comprising:
first USB server means in communication with the data network and a first one of the host computers, the first USB server means having a first network address on the Ethernet data network;
second USB server means in communication with the data network and a second one of the host computers, the second USB server means having a second network address on the Ethernet data network; and
a USB client in communication with the data network and the USB device, the USB client including:
i) means for establishing communications paths with the first and second USB server means,
ii) means for configuring an association module in the USB client with a first association between the USB client and the first USB server and a second association between the USB client and the second USB server;
iii) means for establishing a data transfer path with the first USB server means, the data transfer path enabling passing data between the USB client and the first USB server means over the data network, and
iv) means for sending a busy message to the second USB server means over the communications path established with the second USB server means when the data transfer path is established with the first USB server means.

29. The system of claim 28, wherein the USB client is connected to a single USB device.

30. A USB client apparatus for controlling sending and receiving of universal serial bus ("USB") messages between a plurality of host computers and an associated client device over a data network, each host computer having an associated USB server in communication with the data network, the USB client apparatus comprising:
a multi-host controller in communication with the data network, the multi-host controller configured to:
i) establish communications paths with the USB servers,

ii) configure an association module in the USB client with a first association between the USB client and the first USB server and a second association between the USB client and the second USB server;

iii) establish a data transfer path with a first one of the USB servers, the data transfer path enabling the sending of data between the USB client and the first USB server over a data network, the data network consisting of the Internet, an intranet, an extranet, a local area network, a wide area network, or a combination thereof, and

iv) send a busy message to a second one of the USB servers when the data transfer path is established with the first USB server.

31. The USB client apparatus of claim **30**, further comprising:

a USB device adaptor interfacing with the client device and configured to:

i) receive a USB message from the client device,

ii) translate the USB message to a network format suitable for sending over the data transfer path,

iii) receive a network message from the data network, and

iv) translate the network message to a USB format suitable for providing to the client device.

32. The USB client apparatus of claim **30**, the USB client apparatus further comprising:

a stream queue configured to store stream data for sending to or receiving from the data transfer path.

33. The USB client apparatus of claim **30**, the multi-host controller further configured to:

iv) send an acknowledge message to the first USB server over the communications path established with the first USB server.

34. The USB client apparatus of claim **33**, the USB client apparatus further comprising:

a message queue configured to store the busy and the acknowledge messages for sending to the data network.

35. The USB client apparatus of claim **30**, wherein the USB client is connected to a single USB device.

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